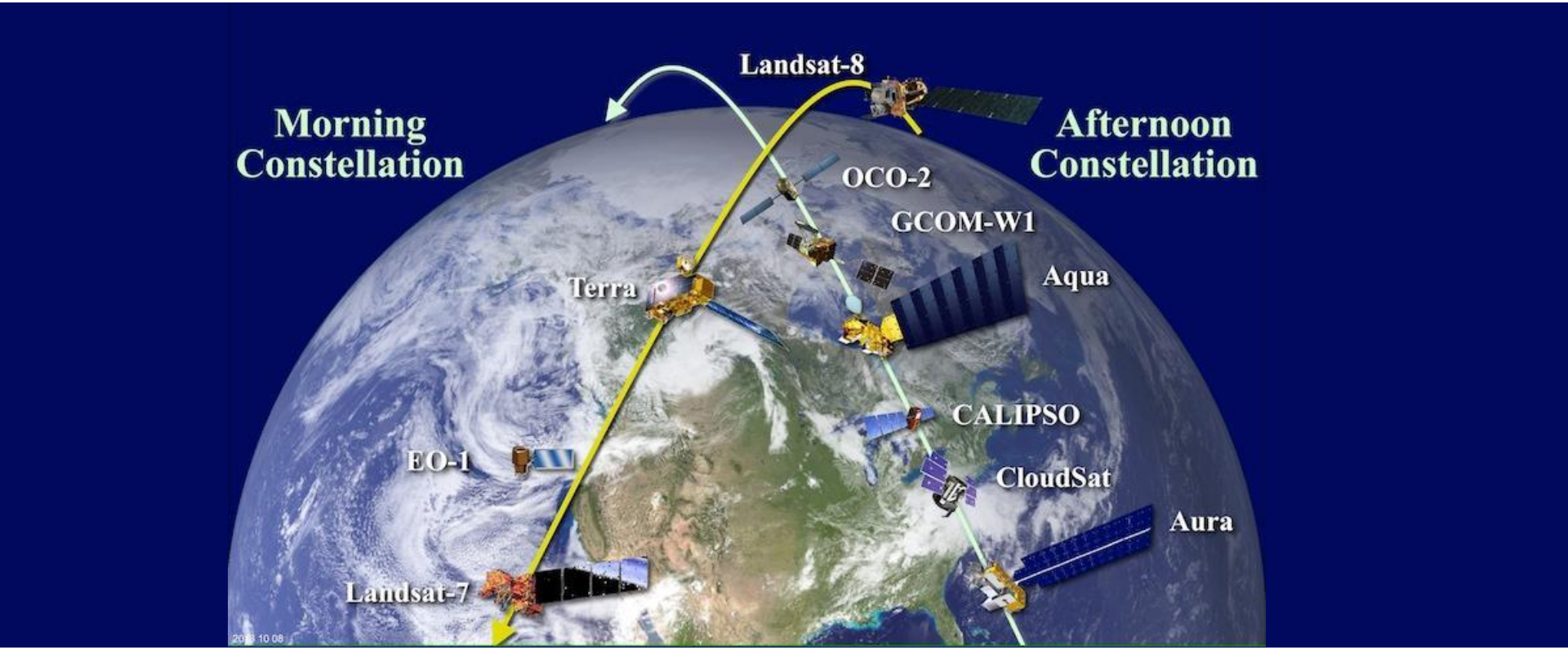
International Earth Science Constellations (ESC)



INTRODUCTION

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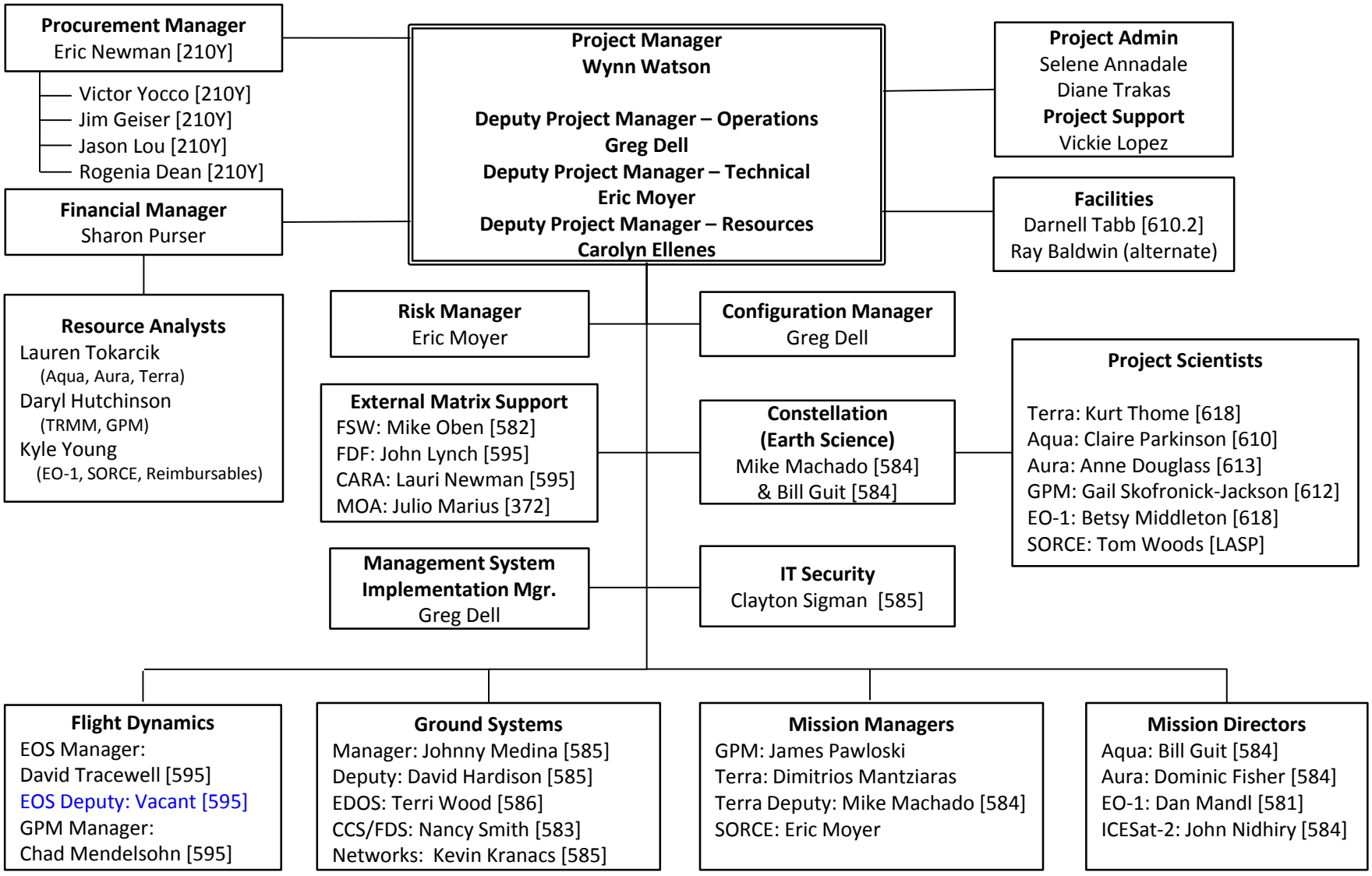
NASA/Goddard Space Flight Center

Welcome

- ***Welcome to all the members of the Mission Operations Working Group (MOWG) of the International Earth Observing Morning and Afternoon Constellations!***
- ***Welcome also to our guests from NOAA.***
- ***Welcome to our telecon participants.***
- ***"THANK YOU" to our hosts – CloudSat***

ESMO Project Organization

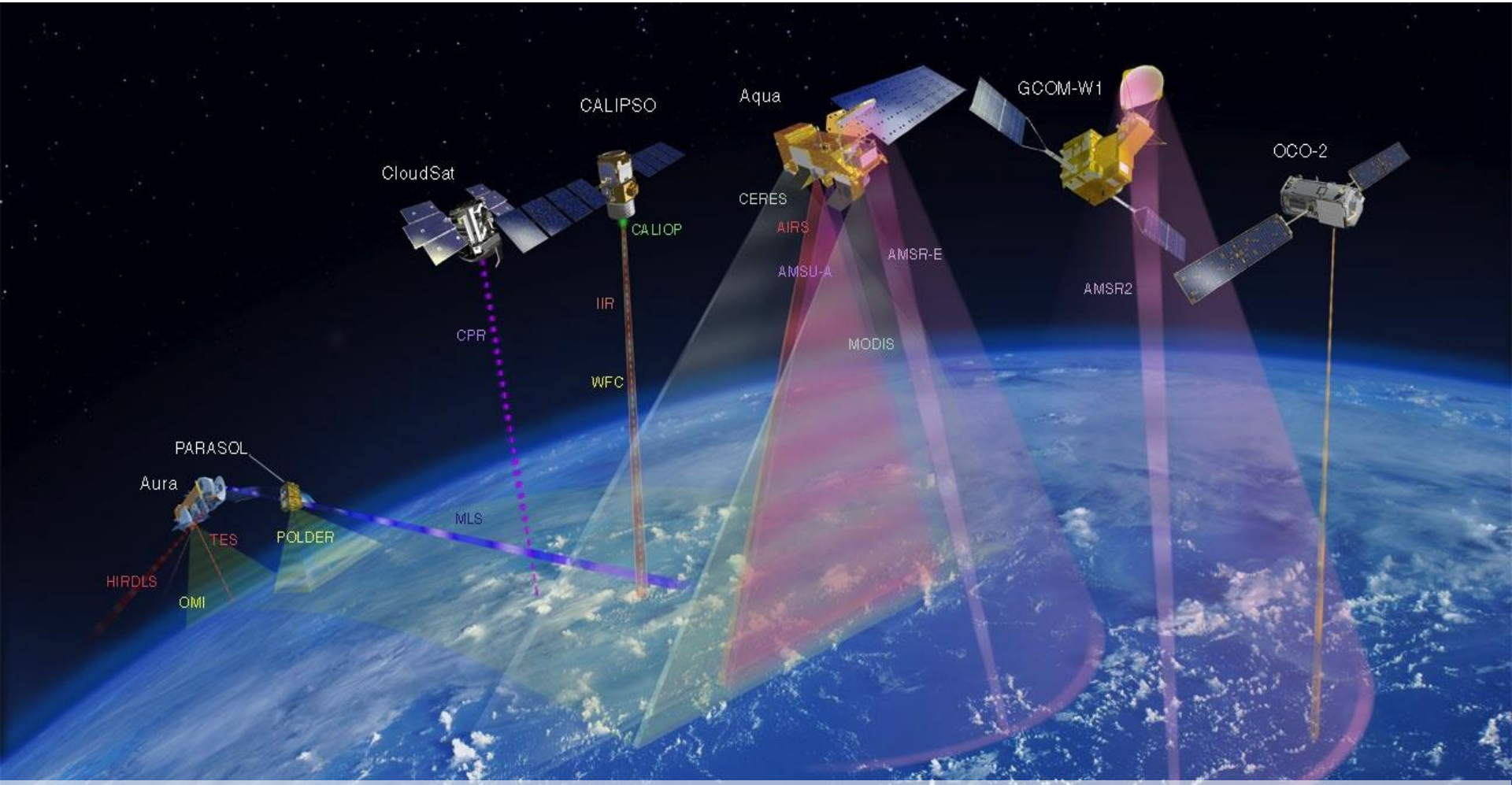


MOWG Charter

The Constellation mission teams enable nearly simultaneous science observations by coordinating their operations and cooperating with each other to ensure the safety of the constellations.

Mission Operations Working Group
September 27-29, 2016

A-Train Science Graphic
(*from Steve Platnick, A-Train Project Scientist*)



The Earth Science Mission Operations (ESMO) Project at the NASA Goddard Space Flight Center (GSFC) leads the Morning and Afternoon Constellation mission operations working group (MOWG) to address constellation safety. The MOWG goal is to ensure the safety of the constellation satellites to enable/maximize coincidental observations.

Constellation History

- **Morning Constellation** officially began in 1999 with the Landsat-7 launch in April and Terra launch in December. EO-1 and SAC-C successfully joined in November 2000. Landsat-8 launched in February 2013.
- **Afternoon Constellation** (A-Train) began with the Aqua launch in May 2002, followed by Aura in July 2004, PARASOL in December 2004, and the joint CALIPSO/CloudSat launch in April 2006 ("formation flying")
- **A-Train Mission Operations Working Group (MOWG)** officially met for the first time in March 2003, preceded by exploratory discussions between LaRC (John Stadler) and GSFC in 2002 (Angie Kelly, Bill Guit and Lauri Newman)
- **Later A-Train missions followed:**
  - **OCO (2010) and Glory (2011)** launches failed due to launch vehicle fairing problems
  - **GCOM-W1** successfully launched in May 2012
  - **OCO-2** successfully launched in July 2014

- **Next mission(s)**: ?

Significant Meeting Topics

- **NASA HQ Perspective**
- **TanSat Update**
- **Current state of the missions**
- **Long term extended missions operations plans**
  - Landsat-7 Exit Plans and Terra Exit Plan updates
  - EO-1 End of Mission Plans
  - Aqua extended mission options
- **Spring 2017 Aqua IAM Series Plans**
- **CCS Future Release Plans and Demos**
- **CARA updates (changes since last MOWG)**
- **Special Topics**
  - Landsat 9 by USGS
  - SNPP/Sentinel-5 loose formation flying overview by NOAA
- **Science Symposium plans (April 2017)**

State of the Constellations

- **Morning Constellation**
  - Terra and its 5 instruments are performing nominally, except ASTER SWIR.
    - Terra safehold in February
  - Landsat 7 and Landsat 8 are performing nominally
  - EO-1 is currently ~23 km below Landsat 7/8 & Terra; continuing science observations
- **Afternoon Constellation**
  - Aqua, Aura, CALIPSO, GCOM-W1, and OCO-2 are performing nominally
  - CloudSat is operating in Daylight-only Operation (Do-Op) mode; formation flying with CALIPSO

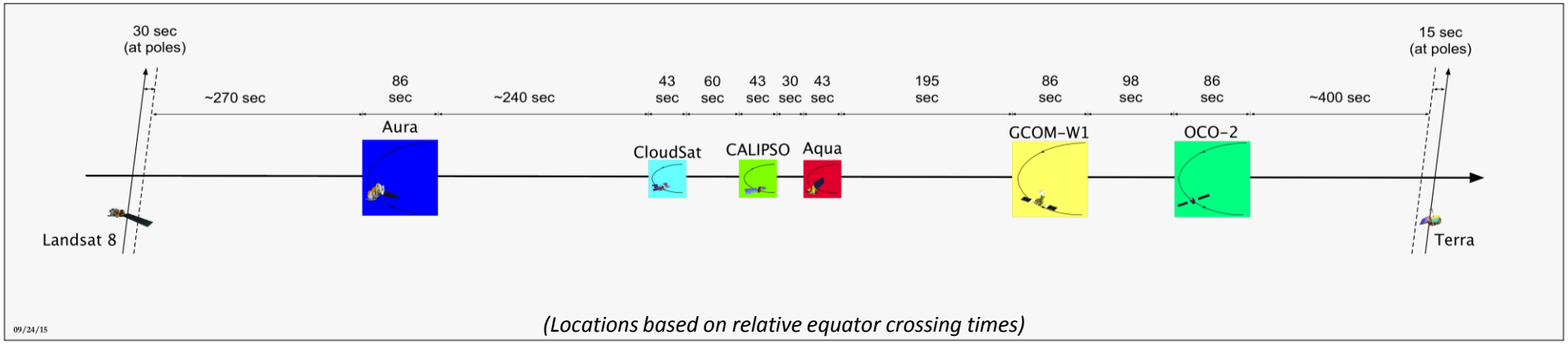
Constellations are operating successfully and producing valuable science data
Excellent cooperation! Still growing and learning!

Constellation Mission Operations Working Group (MOWG) Meeting
Boulder, Colorado
April 13-15, 2016

Since the last meeting . . .

- A-Train annual inclination adjust maneuvers (IAMs) campaign completed in June
- CCS Release 7.2 deployed in August
- Landsat-7 planning for their exit
- More Terra exit options were analyzed
- Aqua has begun to look at extended mission options
- Orbital debris continues to complicate our station-keeping:
  - Aqua, CALIPSO, CloudSat, and GCOM-W1 all had control box excursions
  - GCOM-W1 performed its first-ever retrograde maneuver
- TanSat progressing toward their launch, however it's not exactly clear where TanSat will fly.

Afternoon Constellation
Current Orbital Configuration



(Locations based on relative equator crossing times)

Mission Operations Working Group

September 27-29, 2016

Aqua/Aura IAM Series (Spring 2017)

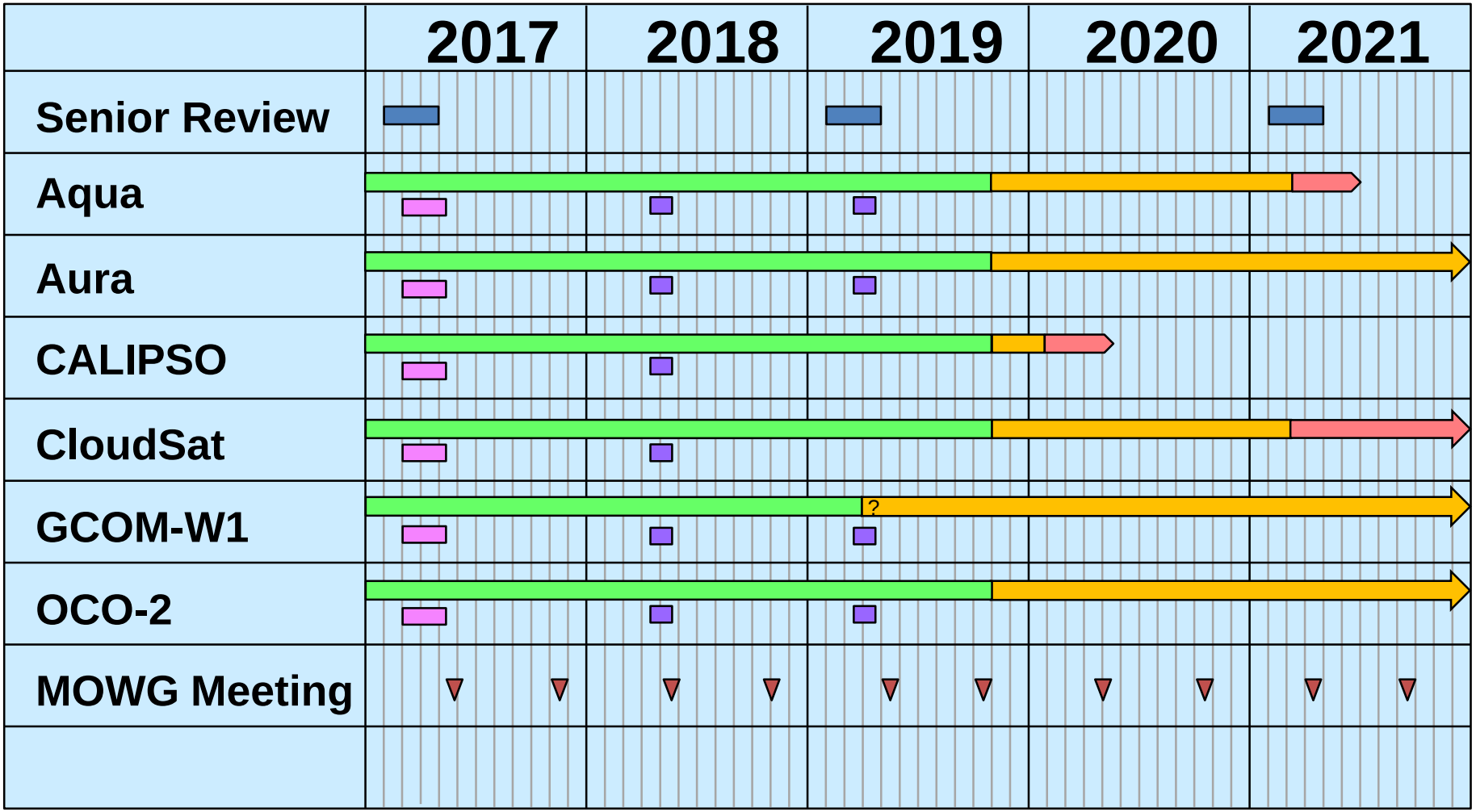
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			March 1 **Aqua IAM#52**	2 **Aura IAM#49**	3	4
5	6	7	8 **Aqua IAM#53**	9 **Aura IAM#50**	10	11
12	13	14	15	16	17	18
19	20 Equinox	21	22 **Aqua IAM#54**	23 **Aura IAM#51**	24 Ideal date (delta-i centered at node crossing)	25
26	27	28	29 **Aqua IAM#55**	30 **Aura IAM#52**	31	April 1
2	3	4	5 Aqua Backup	6 Aura Backup	7	8
9	10	11	12	13	14	15
16 Easter Sunday	17	18	19 [- - - - - - - - - -	20 A-Train Science Symposium	21 - - - - - - - - -]	22**

Mission Operations Working Group

September 27-29, 2016

A-Train Long Range Plan

DRAFT



IAM Proposed IAMs Approved Ops Possible Extended Ops End of Mission Ops

Upcoming Events . . .

• A-Train 3rd International Science Symposium/Conference*	April 19-21, 2017 *(Pasadena, CA)*
• NASA Senior Review	Starting February 2017
• Spring 2017 MOWG Meeting	May / June 2017 *(NASA Goddard?)*
• Fall 2017 MOWG Meeting	To be announced

Mission Operations Working Group
September 27-29, 2016
MOWG Action Items

#	Assignee	Description	Status / Due Date
1604-01	Terra (Mantziaras)	Distribute copies of the Aerospace Corporation report to all teams	**CLOSED** April 18, 2016 The report was distributed (to U.S. teams only due to export restrictions).
1604-02	All MOWG teams	Supply questions about Landsat 7's exit plans to Guy Thayer. The Landsat 7 review is planned for mid-May.	**CLOSED** April 22, 2016 The period for questions was closed.
1604-03	All MOWG teams	Supply questions about Terra's exit plans to Dimitrios Mantziaras.	**CLOSED.** No questions received.
1604-04	Terra (Mantziaras)	Respond to MOWG team questions about Terra's exit plans. Note that responses that require Aerospace Corporation consultation will take much longer (due to contractual reasons).	**CLOSED.** No questions received.
1604-05	ESMO	Review Ops Coordination Plan to determine if the exit plan section needs to be updated.	**OPEN** / Fall 2016 MOWG meeting ***SEE NEXT 2 SLIDES***
1604-06	Vincent	Submit a Constellation Change request that describes the proposed change to reduce the size of the Constellation Envelope by 1 km.	**CLOSED** April 28, 2016 The Constellation Change request was distributed.
1604-07	MOWG teams	Respond to the Constellation Envelope change CCR (see action #1606-06).	**ON HOLD** / **Topic to be re-presented at this MOWG meeting**
Older Action Items			
1506-05	ESMO	Investigate distributing the Hallway display system to the MOWG mission teams.	**OPEN** / Work is progressing **Topic to be presented at this MOWG meeting**

Response to MOWG Action Item 1604-05
Current Operations Coordination Plan Guidelines

Section 1.3 ("Definition of Terms")

"Safe Exit Orbit: An orbit completely outside and below the Constellation Envelope. Note that 'Disposal Orbit' is not defined nor discussed in this document."

Section 1.9 ("Constellation Exit Planning")

"Each mission shall plan to leave the constellation at some point, usually at end of life (i.e., decommissioning) and is required to have a *Constellation Exit Plan* that will state that their satellite will leave in a way that does not threaten other Constellation satellites.

"Mission teams shall maintain a list of trigger events, which if encountered, shall cause the mission team to move its satellite to an orbit external to the Constellation Envelope.

"Missions shall provide a copy of their *Exit Plan* to the MOWG prior to expected exit. The *Exit Plan* shall be reviewed in the context of that mission's position in the Constellation. Issues regarding the *Exit Plan* shall be coordinated and worked through the MOWG.

"Note that this requirement can be satisfied by providing exit plans in an *End Of Mission (EOM) Plan*. An *EOM Plan* is more comprehensive and will include, among other things, the triggers that identify the end of mission."

Mission Operations Working Group
September 27-29, 2016

MOWG Action Item 1604-05
Recommended Changes to the Operations Coordination Plan

Section 1.3 ("Definition of Terms")

"Safe Exit Orbit: An orbit completely outside and below the Constellation Envelope. ~~Note that 'Disposal Orbit' is not defined nor discussed in this document."~~

"Disposal orbit – For the Earth Science Constellations, an orbit used for decommissioning activities at end of mission. The Disposal Orbit is completely outside and below the Constellation Envelope and is sometimes referred to as a "graveyard orbit".

Section 1.9 ("Constellation Exit Planning")

"Each mission shall plan to leave the constellation at some point, usually at end of life (i.e., decommissioning) and is required to have a *Constellation Exit Plan* that will state that their satellite will leave in a way that does not threaten other Constellation satellites.

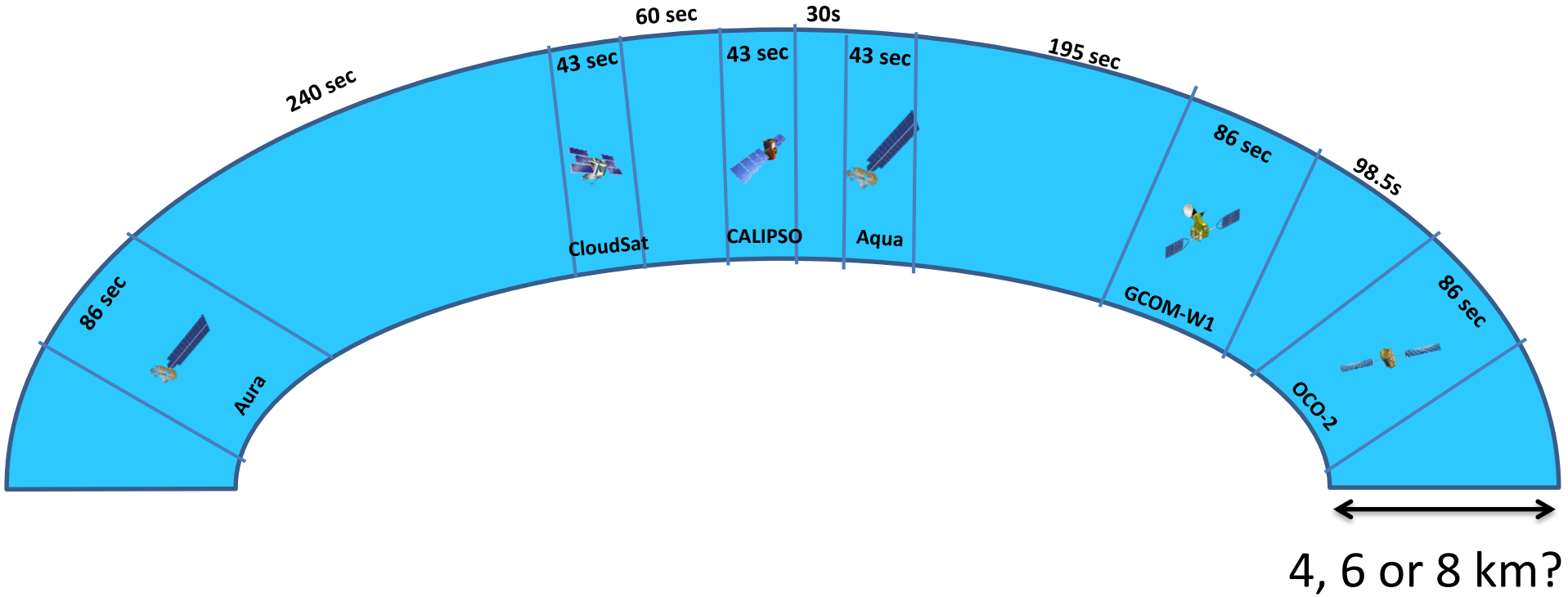
"Mission teams shall maintain a list of trigger events, which if encountered, shall cause the mission team to move its satellite to an orbit external to the Constellation Envelope.

"Missions shall provide a copy of their *Exit Plan* to the MOWG prior to expected exit. The *Exit Plan* shall be reviewed in the context of that mission's position in the Constellation. Issues regarding the *Exit Plan* shall be coordinated and worked through the MOWG.

"Note that this requirement can be satisfied by providing exit plans in an *End Of Mission (EOM) Plan*. An *EOM Plan* is more comprehensive and will include, among other things, the planned Disposal Orbit and the triggers that identify the end of mission."

Mission Operations Working Group
September 27-29, 2016
MOWG Change Request

#	Submitter	Description	Status / Comments and Due Date
17	M. Vincent	Reduce the size of the Constellation Envelope	**Submitted** – April 29 **Revision submitted** – May 31 **Status** – On hold. The topic is to be re-presented at the Fall 2016 MOWG meeting



Meeting Logistics

- **Presentations**
  - Please e-mail your presentation updates to warren.f.case@nasa.gov and nancy.c.herndon@nasa.gov
  - All the presentations will be made available after the meeting via Goddard WebDrive server. Download instructions will be sent.
  - Let us know if your presentations are "***not for public view***".
- **Telecon Number: 1-844-467-6272, code 830887#**
- **Traditional group photo –** Day 1 during afternoon break
- **Wi-Fi**
  - Information To Be Supplied

Tuesday evening - Sandia Peak Tramway

- **Address: 30 Tramway Rd NE at base (18 miles)**
- **Cost: $21/person (to be paid in cash at meeting)**
- **Parking: $2/car. Car pooling encouraged.**
- **Guests are welcome**
- **Schedule:**
  - **Leave meeting no later than 4:45 p.m.**
  - **Board tram at 5:30 ~ 5:45 p.m.**
  - **15 minute ride to top**
  - **Sunset at 6:55 p.m.**
  - **See sunset at top**
- ***High Finance* restaurant at the top if interested (although our Group dinner will be on Wednesday evening).**
- **Please note:**
  - **Altitude: 10,378 ft. / 3163 m (base is 6,559 ft. / 1999m)**
  - **Temperatures: About 20 F / 11 C cooler than at the base, so dress accordingly**
- **URL: http://www.sandiapeak.com/**

- **Map and directions are available**
- ***If you haven't done so already*, let us know if you are interested**

Wednesday evening – Monroe's Mexican Restaurant

- **Monroe's is rated as the #1 Mexican restaurant in Albuquerque.**
- **Address: 6051 Osuna Road Northeast – (their uptown location – 10 miles)**
- **Car pooling encouraged**
- **Guests are welcome**
- **Schedule: 6:30 p.m.**
- **Orders: No pre-orders necessary. Orders will be placed after arrival at the restaurant.**
- **Cost: To be paid at restaurant (separate checks)**
- **URL: http://www.monroeschile.com/**

- **Map and directions are available**
- ***If you haven't done so already*, let us know if you are interested**

ありがとうございます

Arigatou Gozaimasu

Merci

Thank you

Questions?